

NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

October 4, 2006

Flight Data Recorder - 10

Group Chairman's Factual Report
By Sarah McComb

A. EVENT

Location:	Lexington, Kentucky
Date:	August 27, 2006
Aircraft:	Canadair CL-600-2B19 (CRJ-100), N431CA
Operator:	Comair, Flight 5191
NTSB Number:	DCA06MA064

B. GROUP

A group was convened on August 28, 2006.

Chairman:	Sarah McComb Mechanical Engineer National Transportation Safety Board
Member:	Joseph Bracken Senior Staff Engineer Air Line Pilots Association
Member:	Jon Croake-Uleman CRJ-700 Captain Check Airman Comair
Member:	Robert Perkins CF34 Performance General Electric

C. SUMMARY

On August 27, 2006, about 0607 eastern daylight time (EDT), Comair flight 5191, a Bombardier CL-600-2B19 (CRJ-100), N431CA, crashed during takeoff from Blue Grass Airport, Lexington, Kentucky (LEX). The airplane, which had been cleared for runway 22, taxied onto runway 26 instead and ran off the end of runway 26. Of the 47 passengers and 3 crewmembers on board the airplane, 49 were killed, and 1 received serious injuries. The

airplane was destroyed by impact forces and postcrash fire. The flight was operating under the provisions of 14 *Code of Federal Regulations* Part 121 and was en route to Hartsfield-Jackson Atlanta International Airport, Atlanta, Georgia (ATL).

D. DETAILS OF INVESTIGATION

On August 27, 2006, the Safety Board's Vehicle Recorder Division received the following FDR:

Recorder Manufacturer/Model: **L-3 Communications Fairchild Model F1000, 128 Word**
Recorder Serial Number: **102368**

The recorder displayed evidence of external damage due to fire (Figure 1). The internal components were in good condition (Figure 2) and the data were extracted normally from the recorder.



Figure 1: External View of FDR

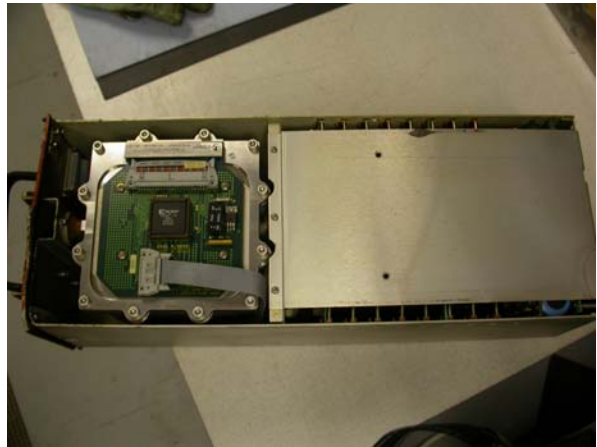


Figure 2: Internal View of FDR

Recorder Description

This model FDR records airplane flight information in a digital format using solid-state flash memory as the recording medium. The F1000 can receive data in the ARINC 573/717/747/542a configurations and can record a minimum of 25 hours of flight data. It is configured to record 128 12-bit words of digital information every second. Each grouping of 128 words (each second) is called a subframe. Each subframe has a unique 12-bit synchronization (sync) word identifying it as either subframe 1, 2, 3, or 4. The sync word is the first word in each subframe. The data stream is "in sync" when successive sync words appear at proper 128-word intervals. Each data parameter (e.g. altitude, heading, airspeed) has a specifically assigned word number within the subframe. The F1000 is designed to meet the crash-survivability requirements of TSO-C124.

FDR Carriage Requirements

Federal regulations regarding the carriage requirements of FDRs on aircraft can be found in the following regulations: 14 CFR 121.343, 14 CFR 121.344, 14 CFR 121.344a and 14 CFR 135.152. In general, for turbine-powered transport category aircraft manufactured on or before October 11, 1991, an FDR must be installed on board that records a minimum of 18 parameters, and for those turbine-powered aircraft that seat between 10 and 19 passengers, the minimum is 22 parameters. Newly manufactured aircraft are required to be equipped with an FDR that records a minimum of 88 parameters. Specifically, the accident aircraft, N431CA, was operating such that it was required to be equipped with an FDR that recorded 57 parameters, as cited in 14 CFR 121.344.

The accident aircraft was not in compliance with the Federal FDR carriage requirements in 14 CFR 121.344, Appendix M. Although the number of parameters recorded was in compliance, the sources of the vertical acceleration and pitch attitude parameters were not updated at rates that met the required recording intervals. Because of problems with the quality of FDR data recorded by several regional jet airplanes, including the CL-600-2B19, the Safety Board issued Safety Recommendation A-03-15 to the Federal Aviation Administration (FAA) on May 16, 2003. Safety Recommendation A-03-15 asked the FAA to do the following:

Require that all Embraer 145, Embraer 135, Canadair CL-600 RJ, Canadair Challenger CL-600, and Fairchild Dornier 328-300 airplanes be modified with a digital flight data recorder system that meets the sampling rate, range, and accuracy requirements specified in 14 *Code of Federal Regulations* Part 121.344, Appendix M.

On September 28, 2005, the Safety Board classified Safety Recommendation A-03-15 as "Open-Acceptable Response." Since issuing the recommendation, the Safety Board has continued to see problems in the vertical acceleration and pitch parameter recording intervals from the FDRs downloaded for other CL-600-2B19 investigations, including the October 14, 2004, accident involving a Bombardier CL-600-2B19 operated by Pinnacle Airlines (doing business as Northwest Airlink) that crashed in a residential area in Jefferson City, Missouri.¹

Recording Description

The FDR recording contained approximately 51 hours of data. Timing of the FDR data is to the nearest second and referred to as FDR subframe reference number (SRN²). The accident takeoff was at the end of the recording. The FDR began recording the event data at about 5:58:50 EDT and its duration was approximately 7 minutes 46 seconds. As

¹ For more information on this accident, see DCA05MA003 at the Safety Board's web site at <<http://www.nts.gov/>>.

² Duration of FDR recording was measured in subframe reference number (SRN), where each SRN equals one elapsed second.

a result of damage to the airplane during the accident sequence, data values at the very end of the recording were invalid, with invalid data recorded for some parameters earlier than others. The data ends at 06:06:36. The invalid data are not included in the plots or tabular data contained in this report.

Time Correlation

Correlation of the FDR data from SRN to the accident local time was established by comparing the timing of the microphone keying parameters recorded on the FDR and the timing of the corresponding transmissions recorded on the CVR. The CVR elapsed time was correlated with local time using the air traffic control transcript (see the Group Chairman's Factual Report of Investigation Cockpit Voice Recorder). The accident flight data has been offset from SRN to local EDT, given by: $EDT = FDR\ SRN - 165062.9$.

Engineering Units Conversions

The engineering units conversions used for the data contained in this report are based on documentation from the aircraft manufacturer. Where applicable, changes to the conversions have been made to ensure the parameters conform to the Safety Board's standard sign convention, of climbing right turns are positive ($CRT=+$)³. Also, offsets were applied to the conversions for lateral acceleration (+0.0352 g's), longitudinal acceleration (+0.0117 g's), and vertical acceleration (+0.0352 g's) to account for the slight bias in the data when the airplane was stationary with no engine power. The parameters presented in this report decoded as expected.

Pressure Altitude

This FDR records the parameter "Altitude" as "Pressure Altitude," which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The "Pressure Altitude" information presented in the FDR plots and in the electronic data has not been corrected for the local altimeter setting at the time of the accident.

Plots

The following plots, Plots 1 through 16, contain information describing the accident on August 27, 2006. Table 1 provides a description of the information contained in the plots:

Plot Number	Time Period	Description
1	06:06:22-06:06:37	Basic parameters
2	06:06:22-06:06:37	Flight controls

³ $CRT=+$ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, any parameter recorded that is indicating an action or deflection, if it induces a climb or right turn, the value is positive. Examples: Right Roll = +, Left Aileron Trailing Edge Down = +, Right Aileron Trailing Edge Up = +, Pitch Up = +, Elevator Trailing Edge Up = +.

3	06:06:22-06:06:37	Miscellaneous discretes, secondary bugs, environment, angle of attack, trim parameters
4	06:06:22-06:06:37	Engines
5	06:06:22-06:06:37	Gear parameters
6	06:06:22-06:06:37	Accelerations
7	06:05:37-06:06:37	Autopilot parameters
8	06:05:37-06:06:37	Basic parameters
9	06:05:37-06:06:37	Flight controls
10	06:05:37-06:06:37	Miscellaneous discretes, secondary bugs, environment, angle of attack, trim parameters
11	06:05:37-06:06:37	Engines
12	05:59:00-06:06:40	Multi-function display (MFD) and radar parameters
13	05:59:00-06:06:40	Basic parameters
14	05:59:00-06:06:40	Flight controls
15	05:59:00-06:06:40	Miscellaneous discretes, secondary bugs, environment, angle of attack, trim parameters
16	05:59:00-06:06:40	Engines

Table 1: Description of Plots 1 through 16

Key events from the data:

- Left and right⁴ magnetic heading values indicate a left turn from about 130° during 05:59:37, reaching 46.3° (06:00:47) and 48.9° (06:00:48), respectively.
- During 06:00:14, Engine 1 N1 began to increase from 0%, reaching 26% during 06:00:44. During 06:01:01, Engine 2 N1 began to increase from 0%, reaching 25% during 06:01:26.
- Control checks began during 06:02:18 and ended about 31 seconds later.
- The right MFD mode range changed from “10 nm” to “40 nm” during 06:02:24.
- Four seconds later, the radar overlay became “active.”
- Left and right magnetic heading values then indicated several turns between 06:02:15 and 06:04:20, finally reaching values of 40.3° and 41.6°, respectively.
- The left MFD mode range changed from “40 nm” to “80 nm” during 06:04:34.
- Longitudinal acceleration data indicates the airplane was not moving between 06:04:36 and 06:05:22.
- As of 06:05:50, both left and right autopilot lateral takeoff modes were “engaged.”
- Left and right magnetic heading indicate a left turn beginning during 06:05:39, reaching 266.5° (06:05:59) and 265.8° (06:06:00), respectively.
- During 06:06:00, Engine 1 and 2 N1’s began to increase, reaching 91% during 06:06:12 and 06:06:13, respectively.
- Left and right computed airspeed began to increase during 06:06:05. Computed airspeed values continued to increase throughout the remainder of

⁴ On this airplane, several parameters are recorded from the applicable left and right systems (e.g. magnetic heading, pitch, roll, etc.). The data is then interleaved to meet the recording frequency requirements in the Federal regulations.

the recording with the left computed airspeed reaching 136.75 knots during 06:06:35.

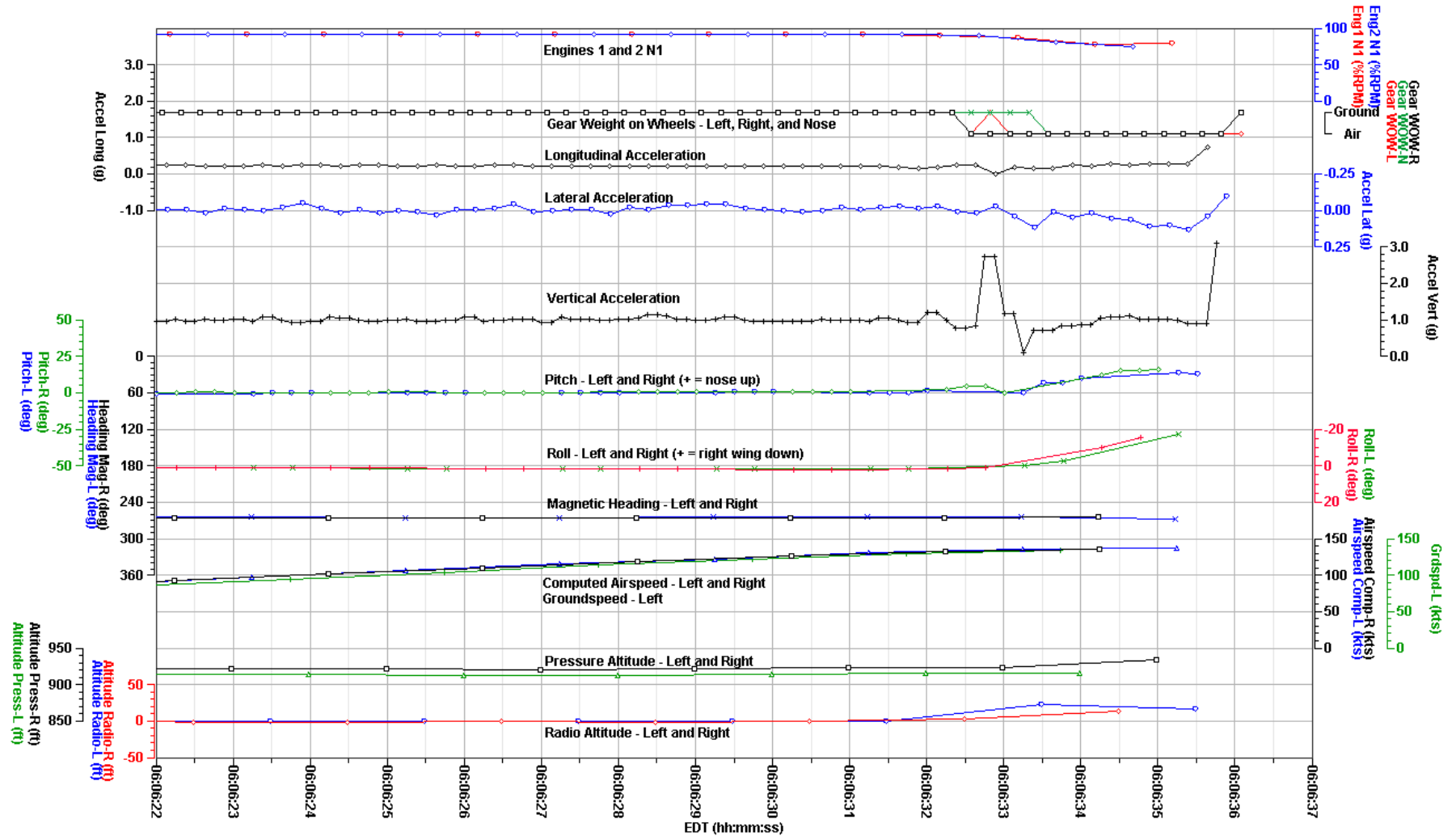
- Left groundspeed values are not valid until 06:06:19.
- During 06:06:30, with a right computed airspeed of 127.00 knots, the left and right control column began to move aft. Left and right elevator began to move trailing edge up the following second. The maximum aft control column position was the right control column value of 10.9° during 06:06:33, with a left computed airspeed of 135.00 knots. The maximum trailing edge up elevator position was the right elevator value of 22.6° during 06:06:32.
- During 06:06:32, right pitch reached 4.7° airplane nose up (ANU). The following second, both the left and right pitch values decreased to 0°. Later that second, the left pitch value increased to 6.7° ANU. Both left and right pitch continued to increase over the next two seconds, with right pitch reaching 15.9° ANU (maximum value recorded). The final pitch value recorded was the left pitch of 12.7° ANU during 06:06:35.
- During 06:06:32, vertical acceleration increased to 1.199 g's, decreased to 0.766 g's, and then increased to 2.742 g's. The following second vertical acceleration decreased to 0.117 g's. The final vertical acceleration value recorded was 3.113 g's during 06:06:35.
- The right stick shaker became "active" during 06:06:33. The following second the left stick shaker and the left and right stick pusher became "active." The final right stick shaker status recorded was "not active" during 06:06:35.
- Left and right angle of attack began to increase during 06:06:32, with the highest value recorded being the left angle of attack of 13.3° during 06:06:35.
- During 06:06:33, the left aileron began to increase in a right wing down direction, reaching a maximum value of 24.9° later that second. The following second, the left flight spoiler increased to 42°.
- Left and right roll began to increase in a left wing down direction during 06:06:33, with the maximum left wing down value being the left roll of 17.4° two seconds later. Lateral acceleration increased to 0.113 g's during 06:06:33 and decreased to 0.014 g's the following second. During 06:06:35, lateral acceleration reached 0.135 g's before a value of -0.096 g's was recorded later that second.
- Beginning during 06:06:33, right rudder pedal was applied and trailing edge right rudder values were recorded the following second. The maximum right rudder pedal was 5.7° during 06:06:34 and the maximum trailing edge right rudder position was 10.1° during the same second.
- During 06:06:32, the left and right gear weight on wheels indicated "air." Later that second, the left gear weight on wheels indicated "ground" before returning to "air" the following second. The nose gear weight on wheels indicated "air" during 06:06:33. The nose and right gear weight on wheels returned to "ground" during 06:06:36.
- Left and right radio altitude values began to increase during 06:06:32 and remain above 0 ft. for the remaining three seconds of data.
- Engine 1 and 2 N1's began to decrease during 06:06:32, reaching final values of 80% (06:06:35) and 74% (06:06:34), respectively.

- Longitudinal acceleration increased from about 0.2 g's during 06:06:31 to 0.250 g's during 06:06:32, decreased to 0.004 g's later that second, and then increased to 0.736 g's during 06:06:35.
- The following parameters remain at these values or settings during the recording:
 - Flap – Left and Right = 21° and 19°, respectively (with the exception of the last 3 seconds of the recording when the flap values decreased during the accident sequence)
 - Flap Lever Position - 20 Deg. = “20 Deg” (parameter not plotted)
 - Pitch Trim Stab Position = 5.2°
 - Secondary Bug V1 = 137 knots
 - Secondary Bug V2 = 145 knots
 - Secondary Bug Vr = 142 knots
 - Secondary Bug Vt = 183 knots
 - Autopilot Indicated Airspeed Selected = 200 knots
 - Autopilot Altitude Selected = 5984 ft.
 - Autopilot Course Selected – Left and Right = 226°
 - Autopilot Heading Selected = 227°
 - MFD Mode – Left and Right = “PPSN Map”

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 25 September 2006

Plot 1: Basic Parameters, 15 seconds

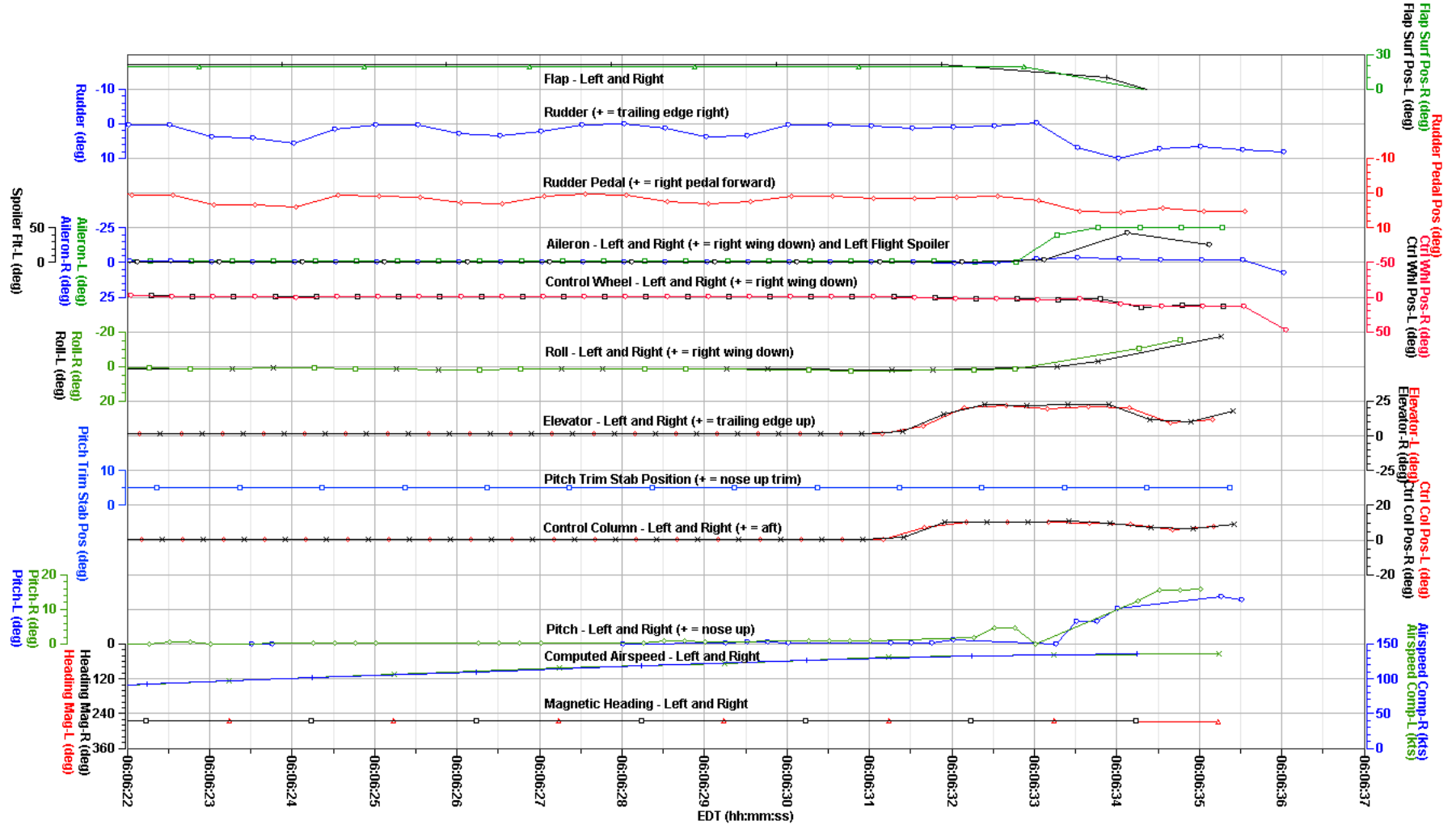
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Factual Report Plot 1

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

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Revised: 25 September 2006

Plot 2: Flight Controls, 15 seconds

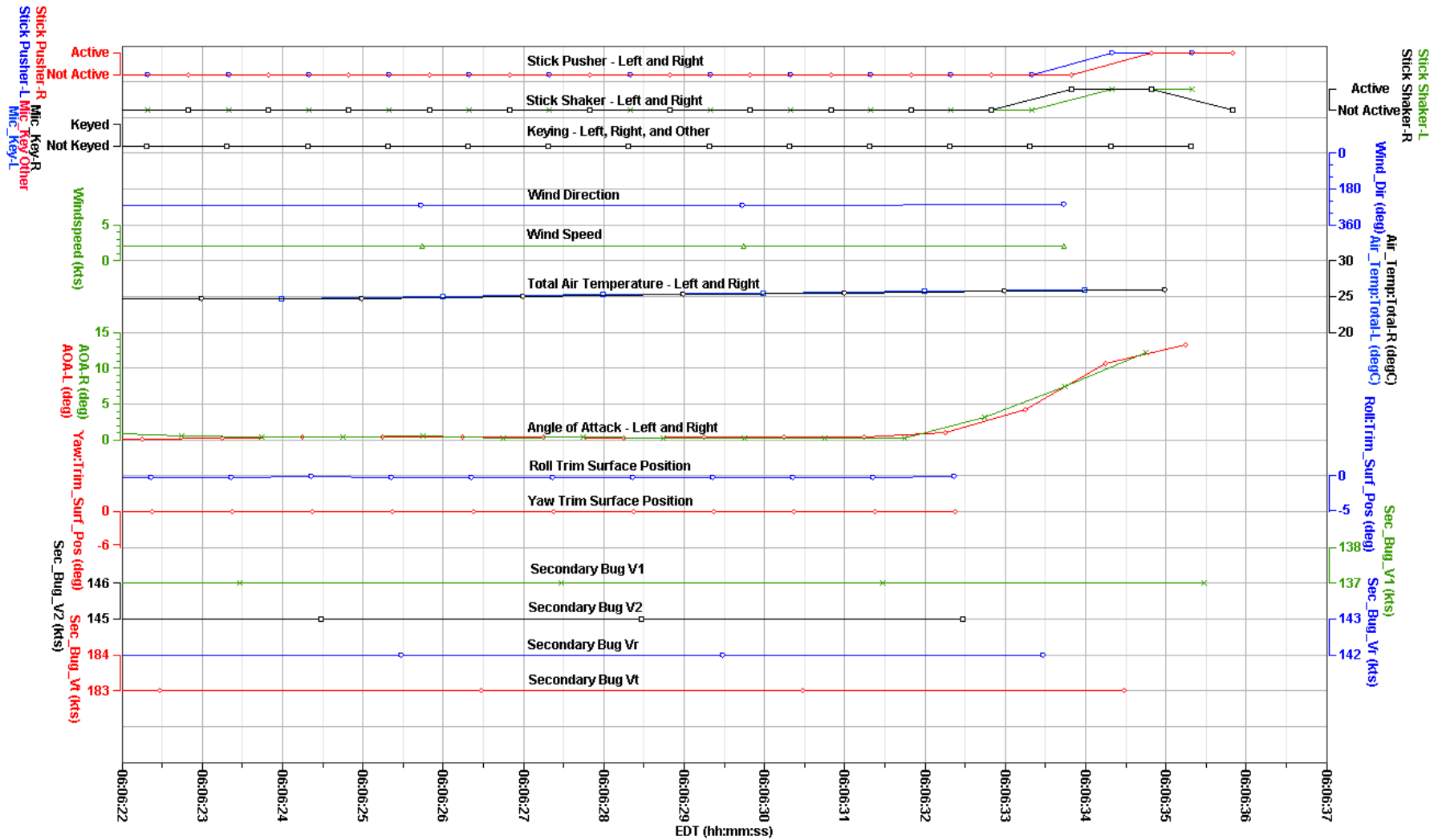
National Transportation Safety Board

Factual Report Plot 2

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



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Plot 3: 15 sec.

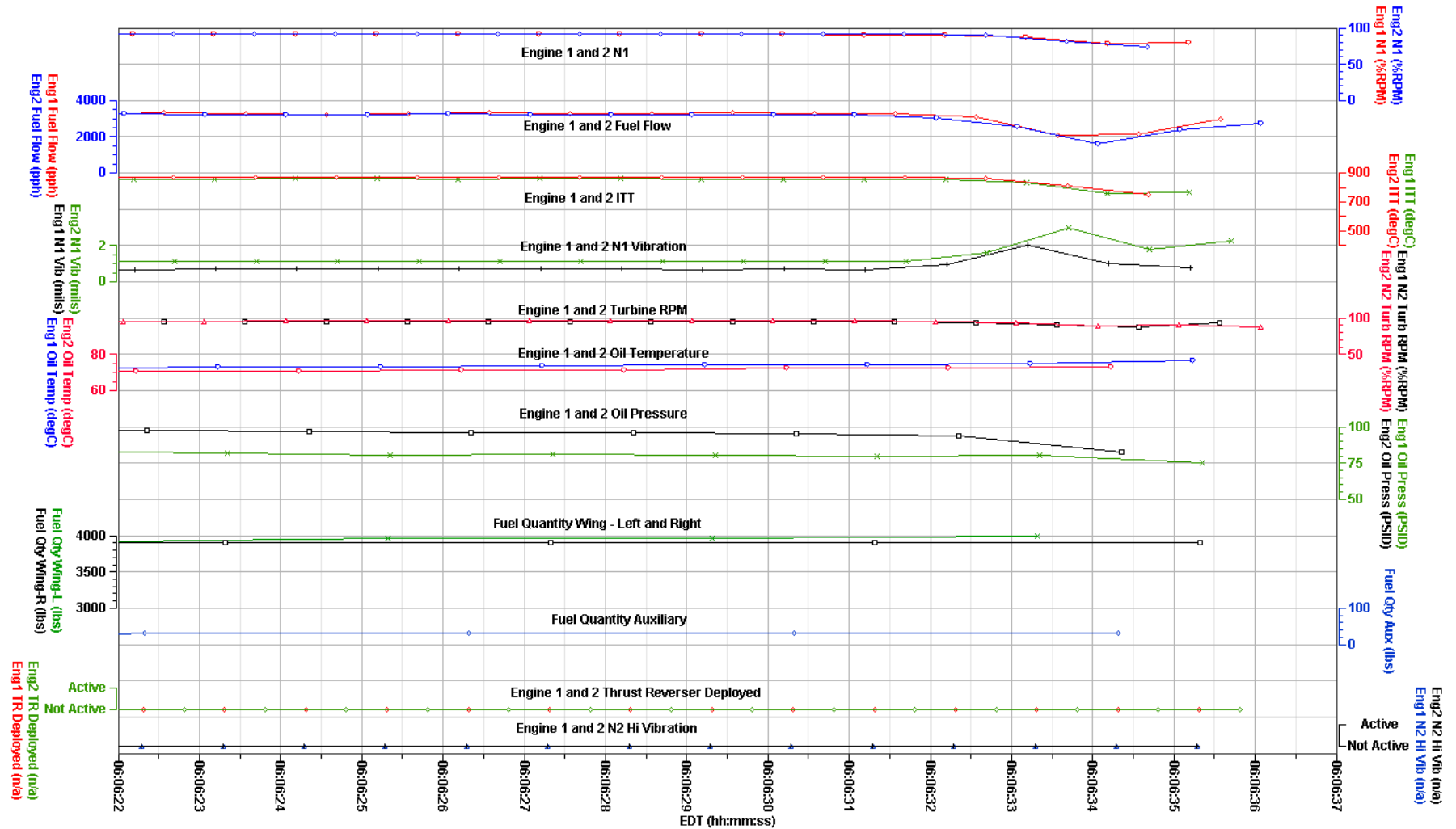
National Transportation Safety Board

Factual Report Plot 3

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



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Plot 4: Engine Parameters, 15 seconds

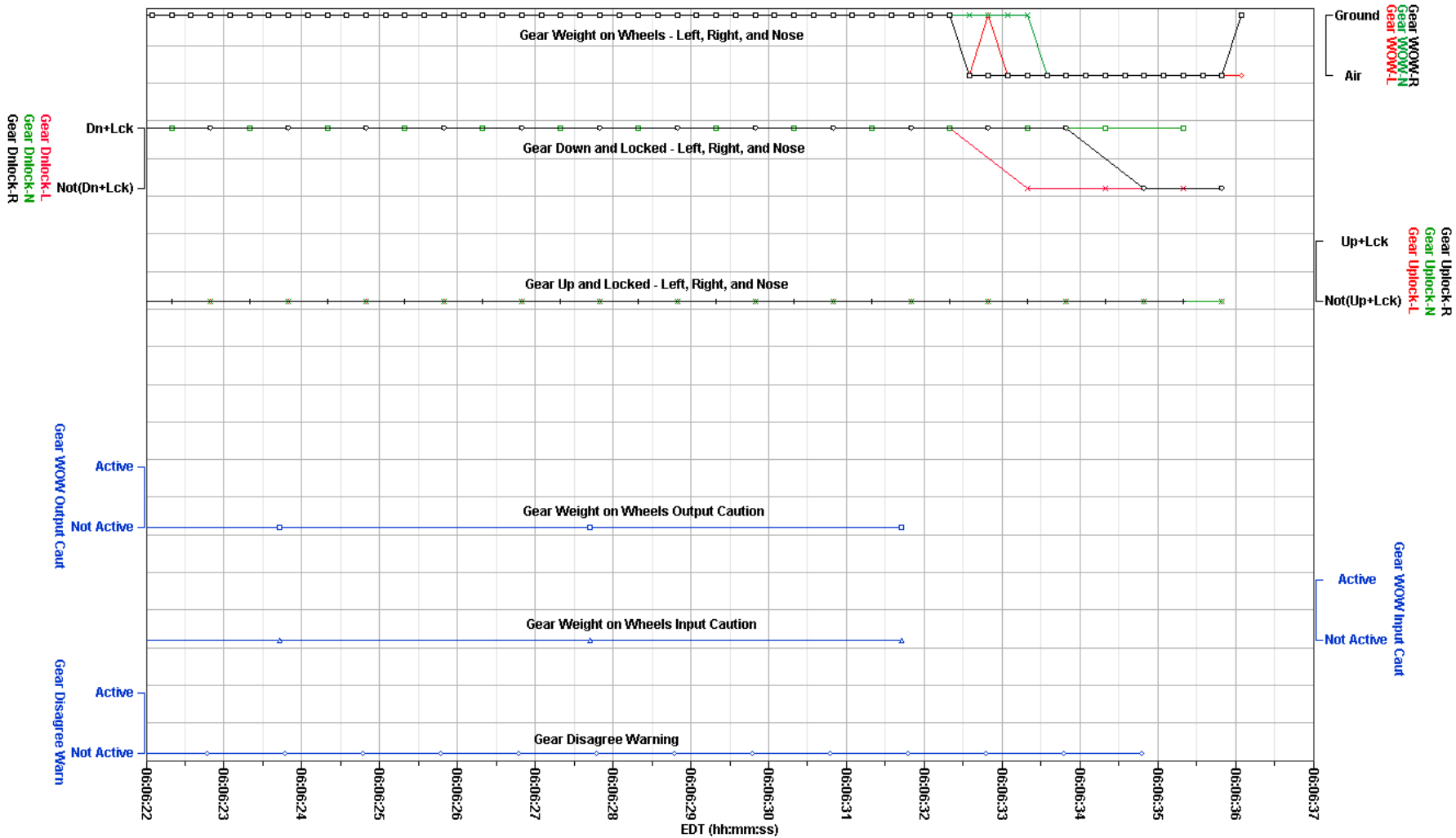
National Transportation Safety Board

Factual Report Plot 4

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



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Plot 5: Gear Parameters, 15 seconds

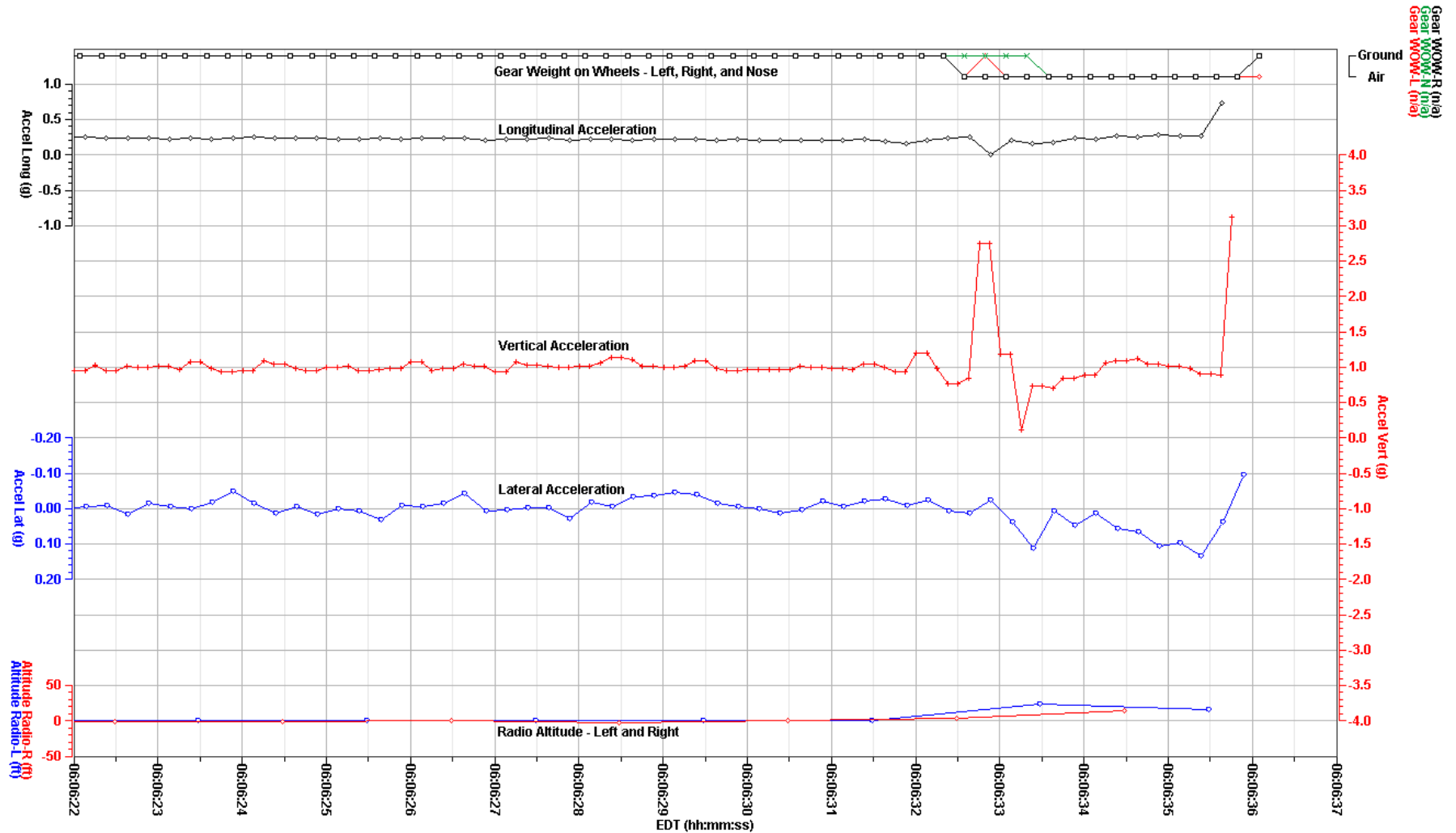
National Transportation Safety Board

Factual Report Plot 5

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

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Accelerations, 15 seconds

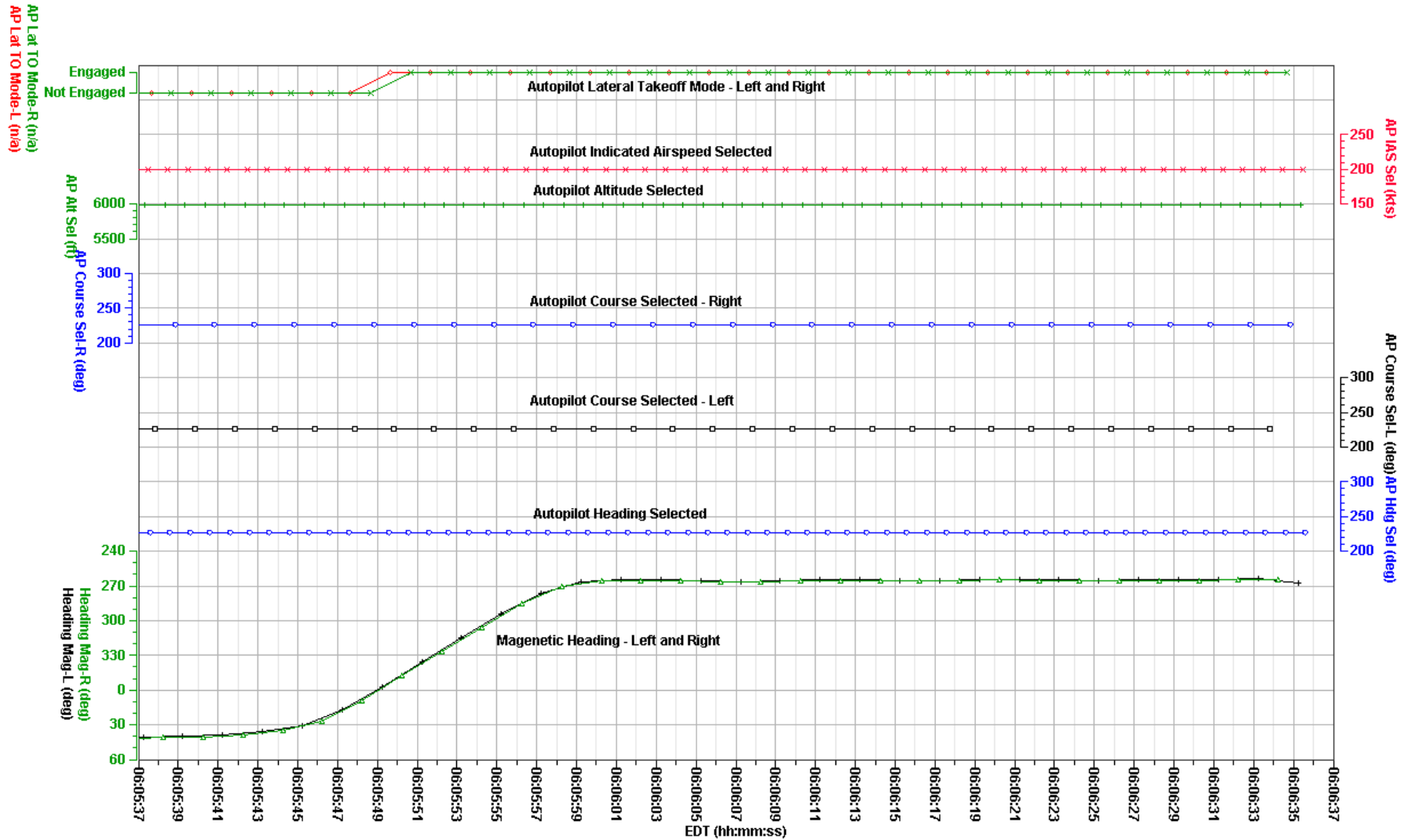
National Transportation Safety Board

Factual Report Plot 6

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 27 September 2006

Plot 6: Autopilot Parameters, 60 seconds

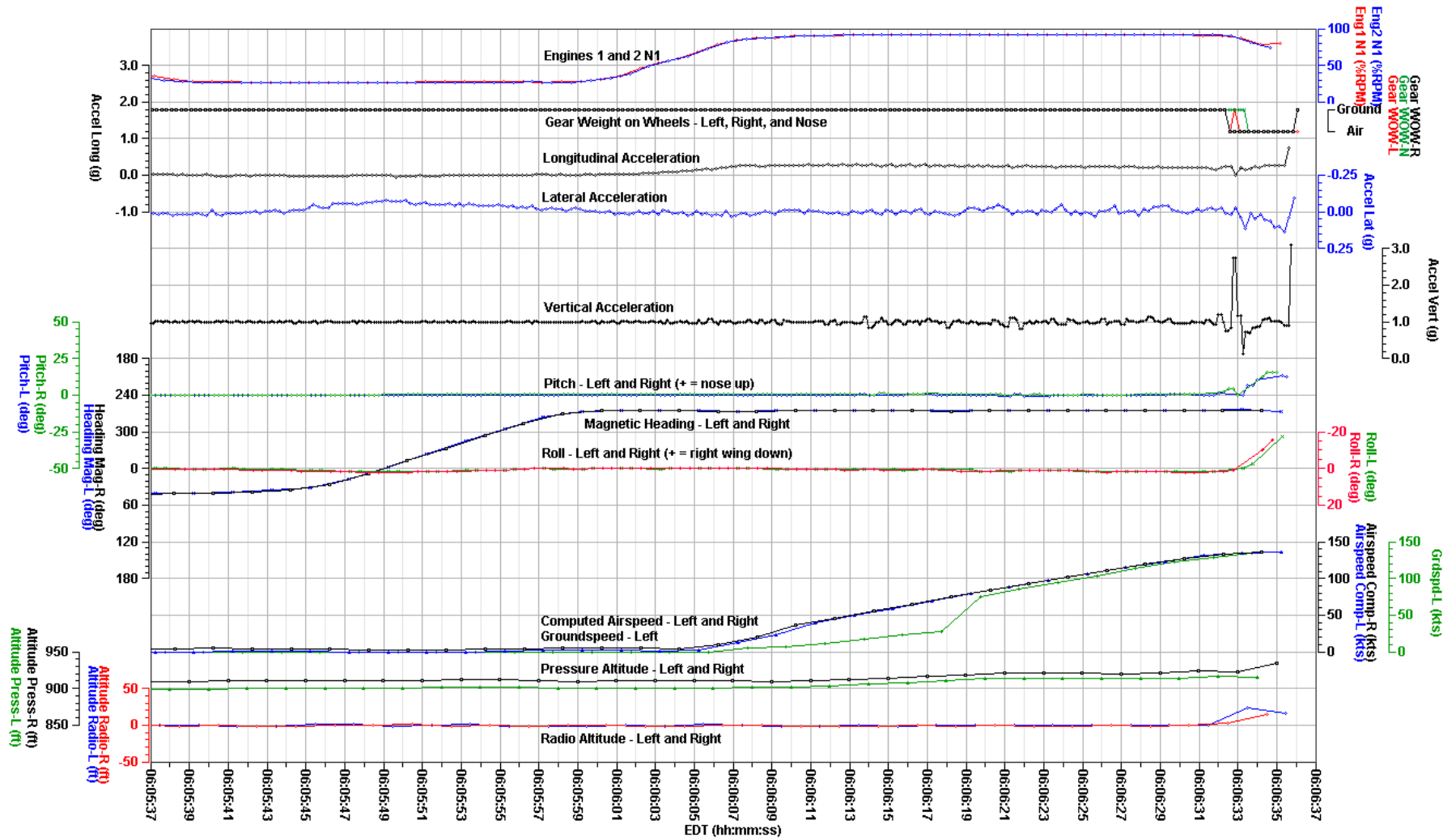
National Transportation Safety Board

Factual Report Plot 7

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 25 September 2006

Plot 1: Basic Parameters, 60 seconds

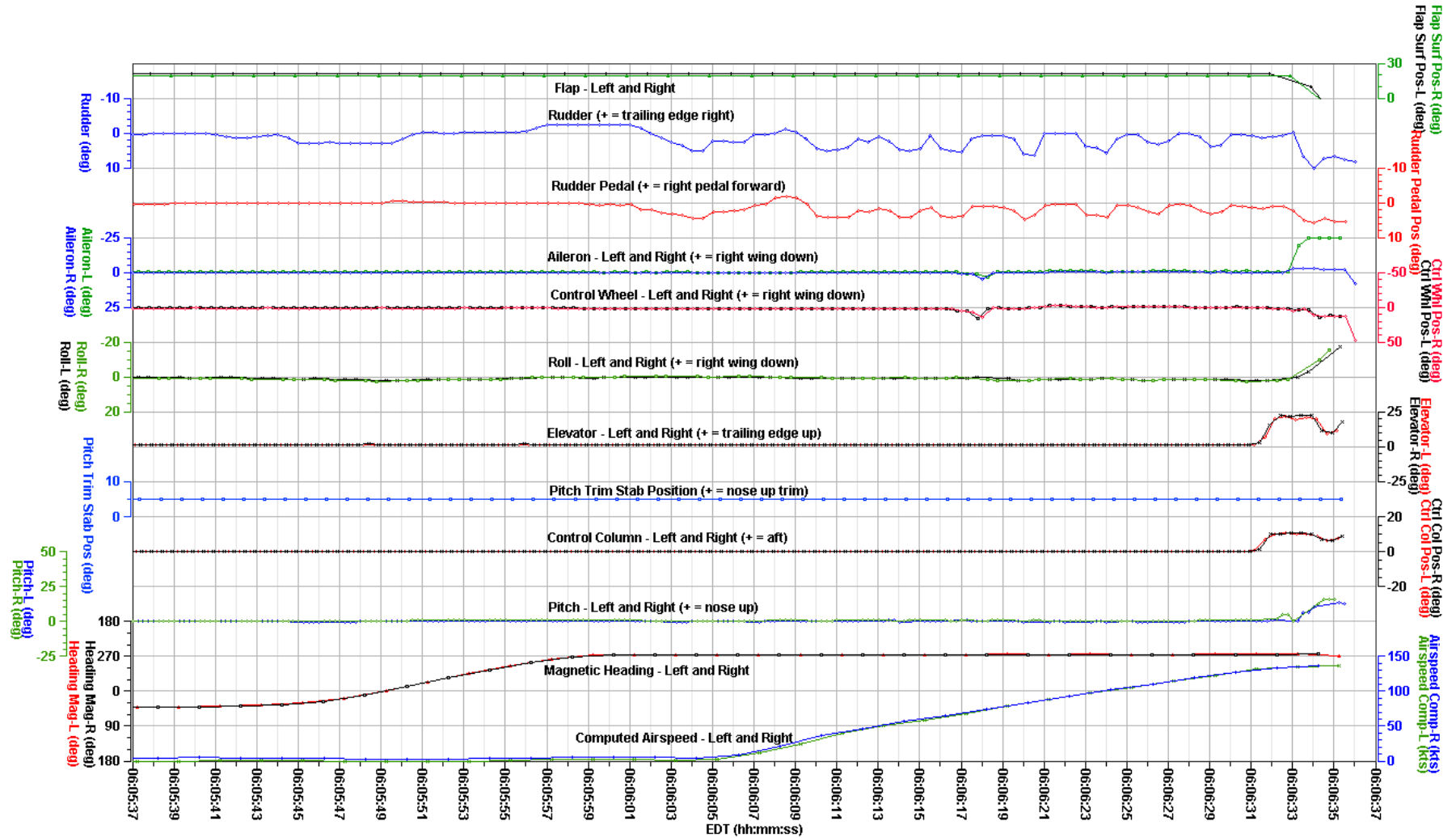
National Transportation Safety Board

Factual Report Plot 8

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 25 September 2006

Plot 2: Flight Controls, 60 seconds

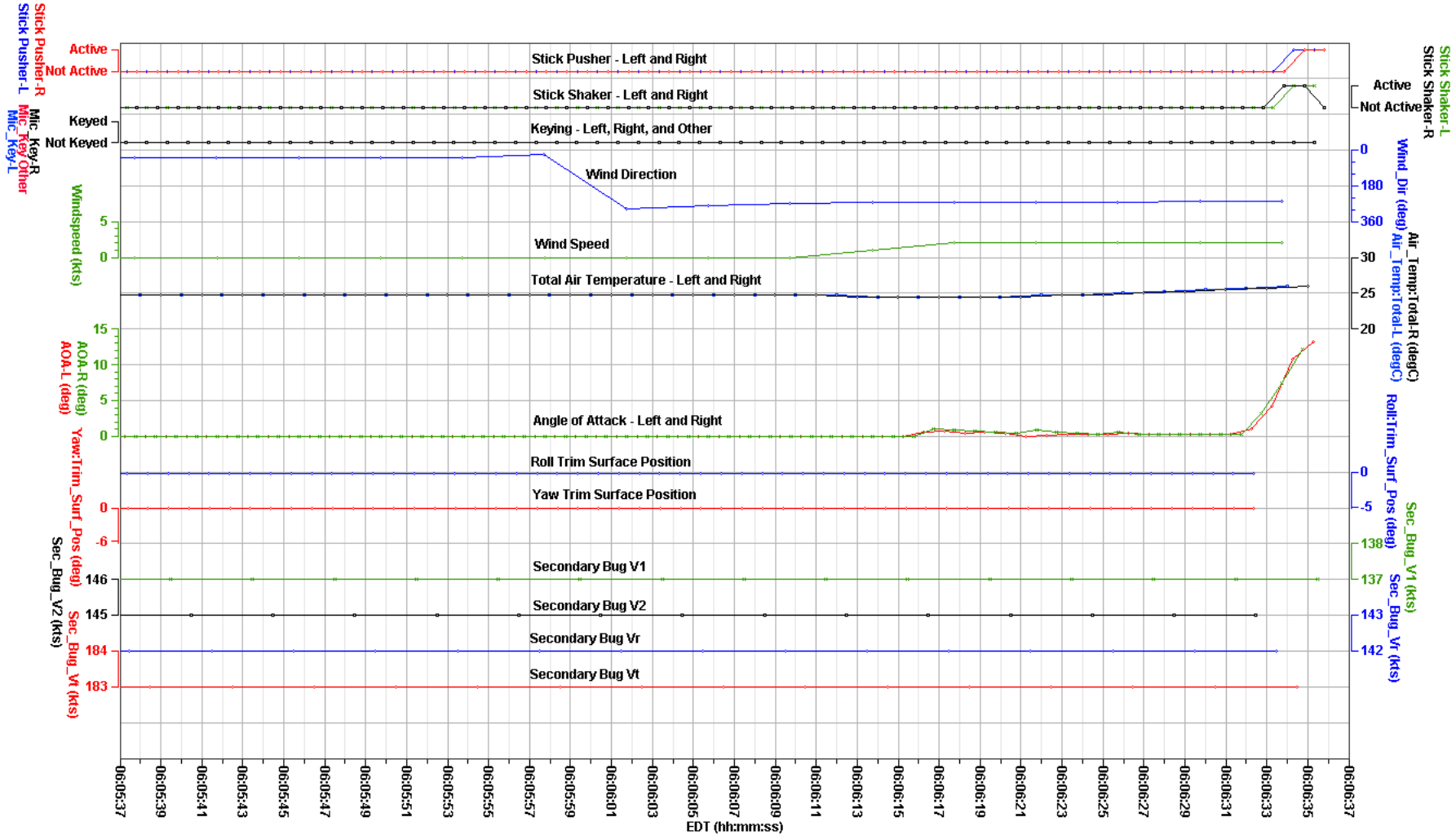
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Factual Report Plot 9

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 25 September 2006

Plot 3: 60 sec.

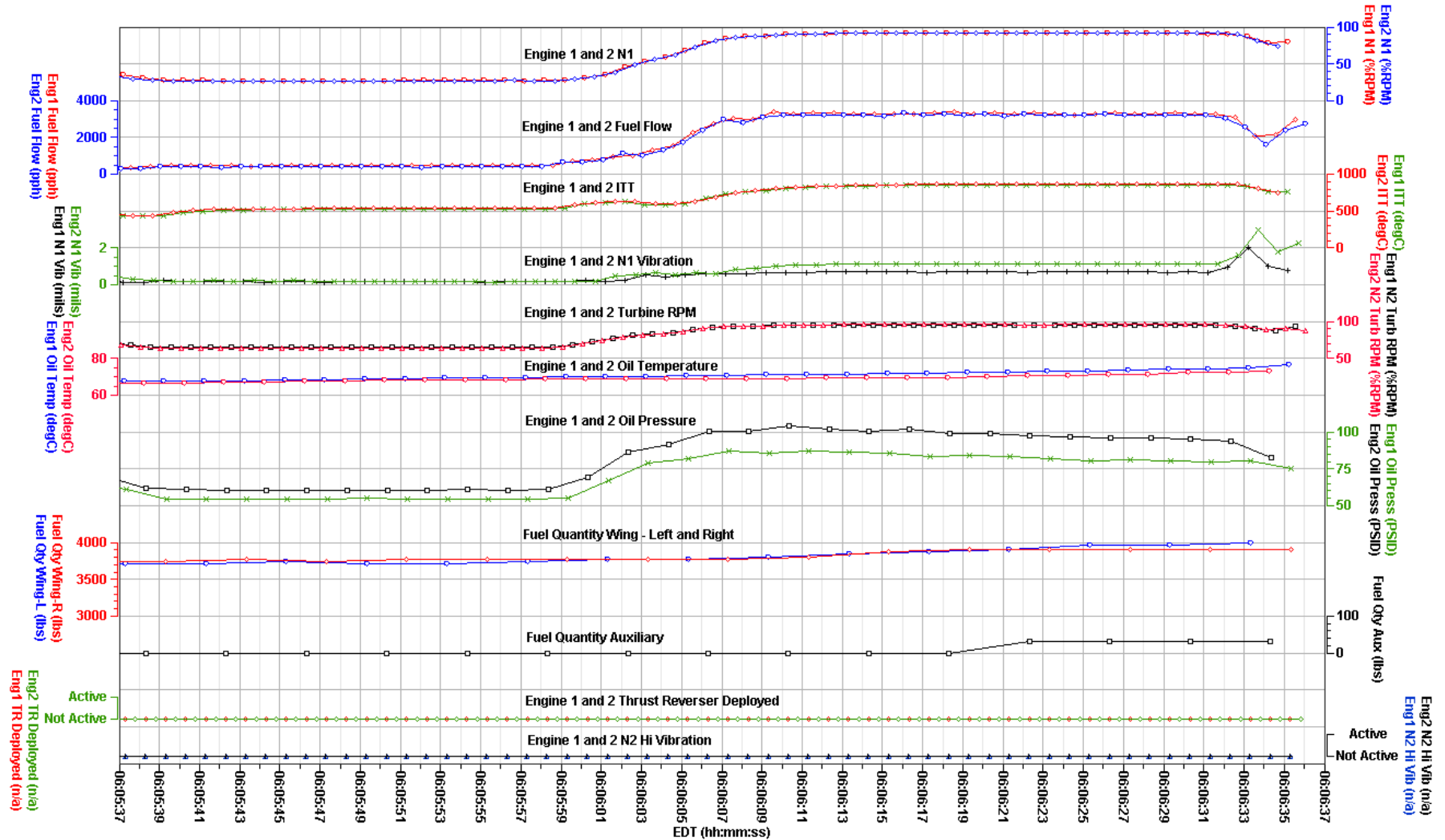
National Transportation Safety Board

Factual Report Plot 10

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 25 September 2006

Plot 4: Engine Parameters, 60 seconds

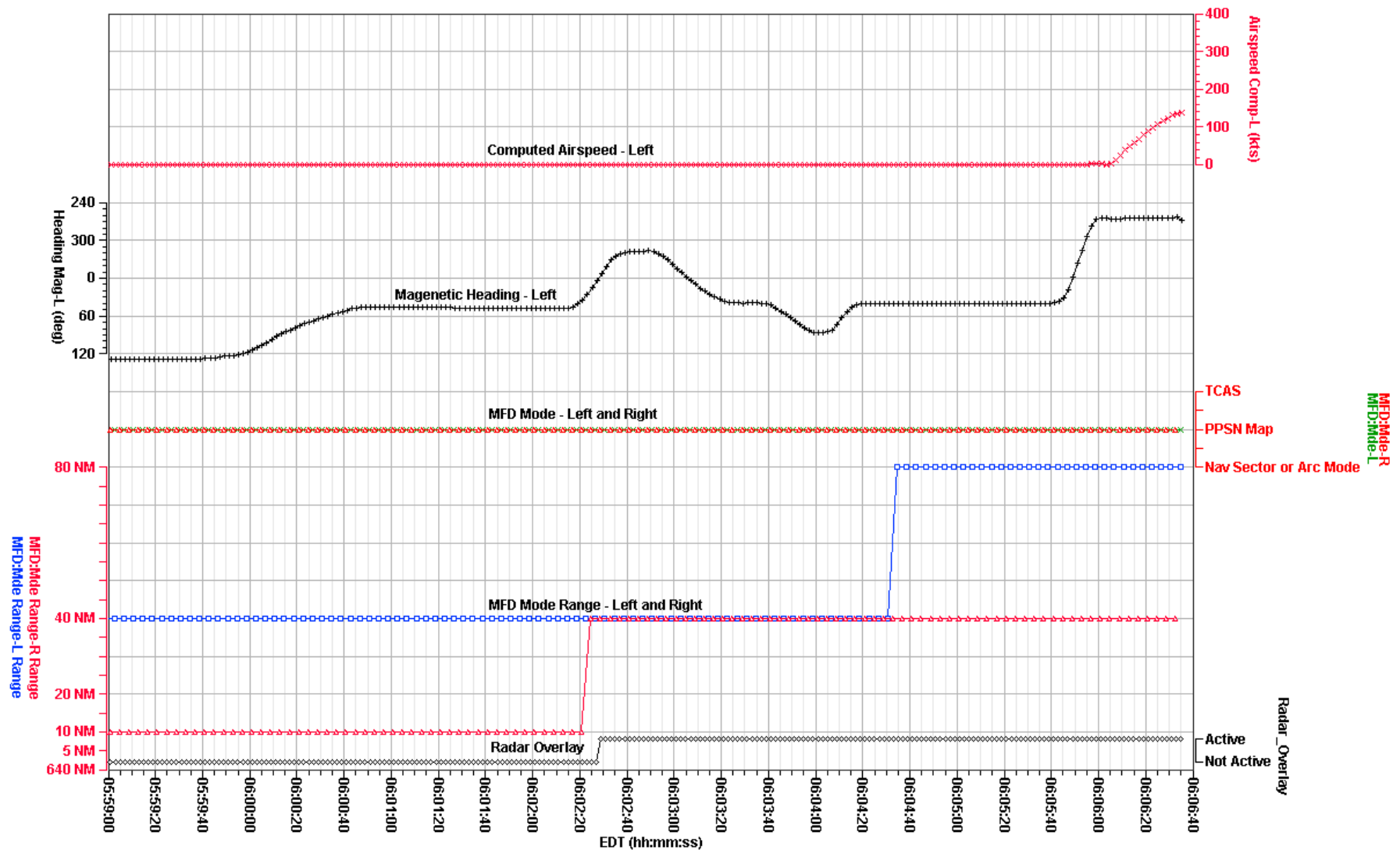
National Transportation Safety Board

Factual Report Plot 11

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 4 October 2006

MFD and Radar Parameters, 460 seconds

National Transportation Safety Board

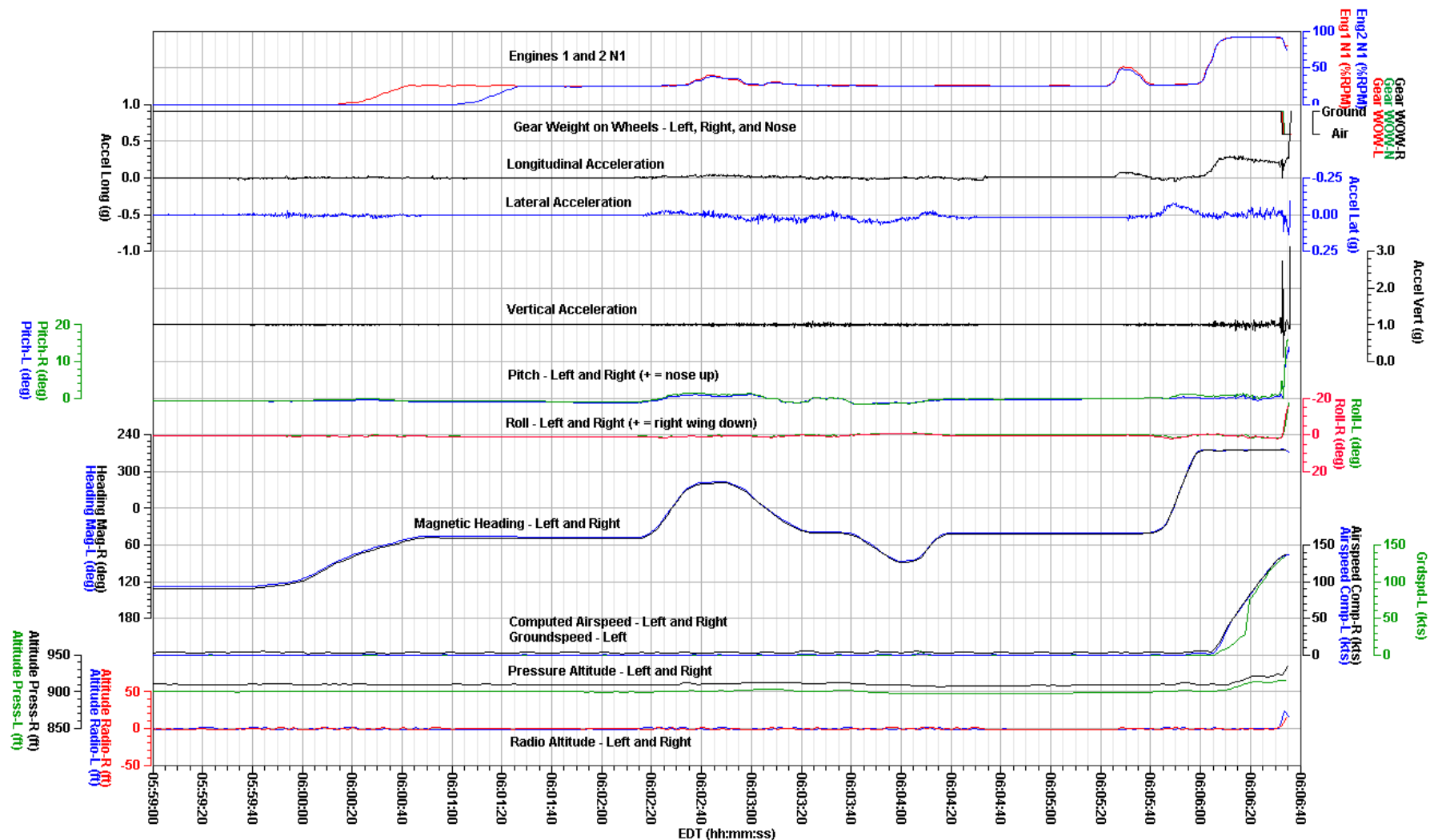
Factual Report Plot 12

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FDR Factual Report, page 10-19

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 25 September 2006

Plot 1: Basic Parameters, 460 seconds

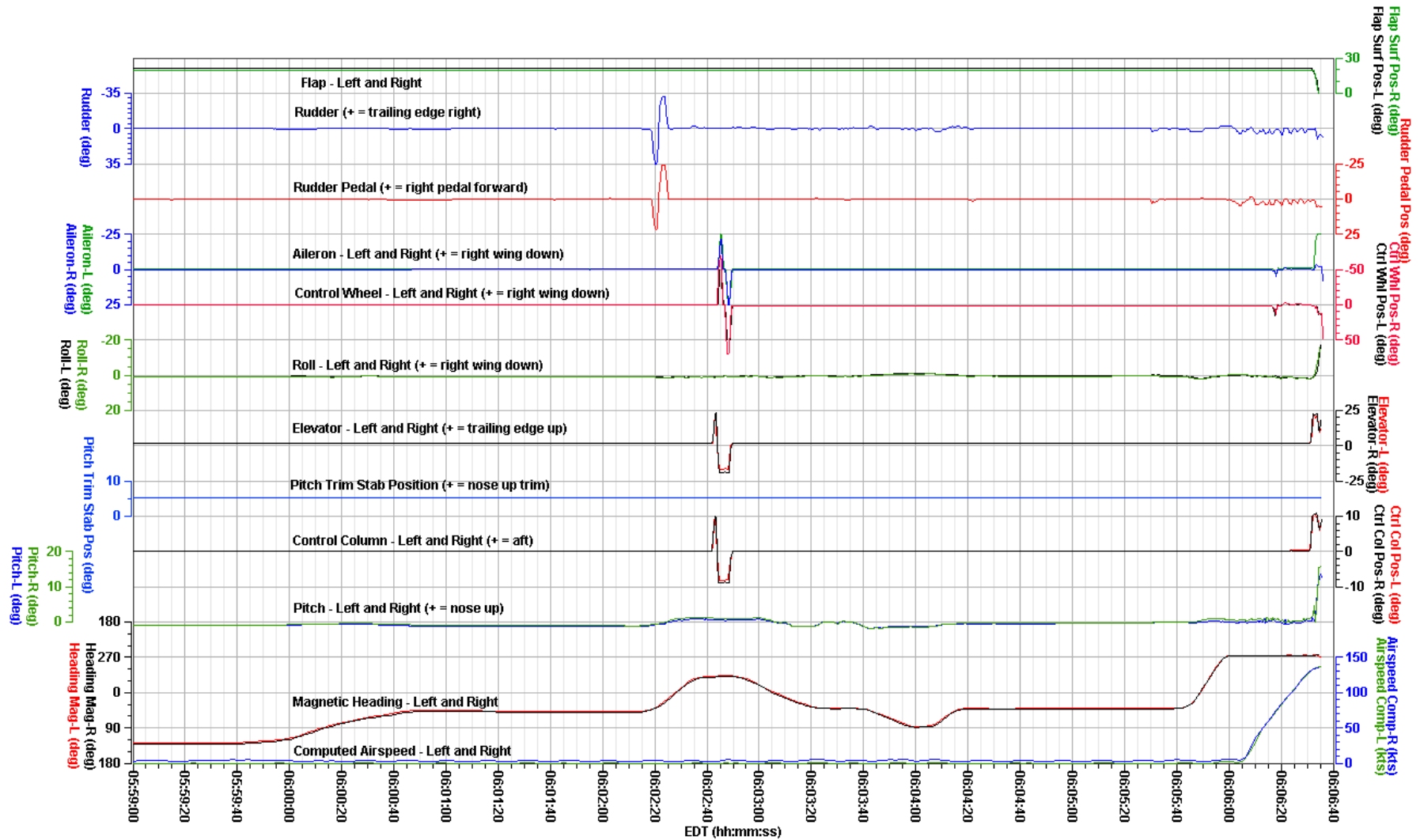
National Transportation Safety Board

Factual Report Plot 13

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 25 September 2006

Plot 2: Flight Controls, 460 seconds

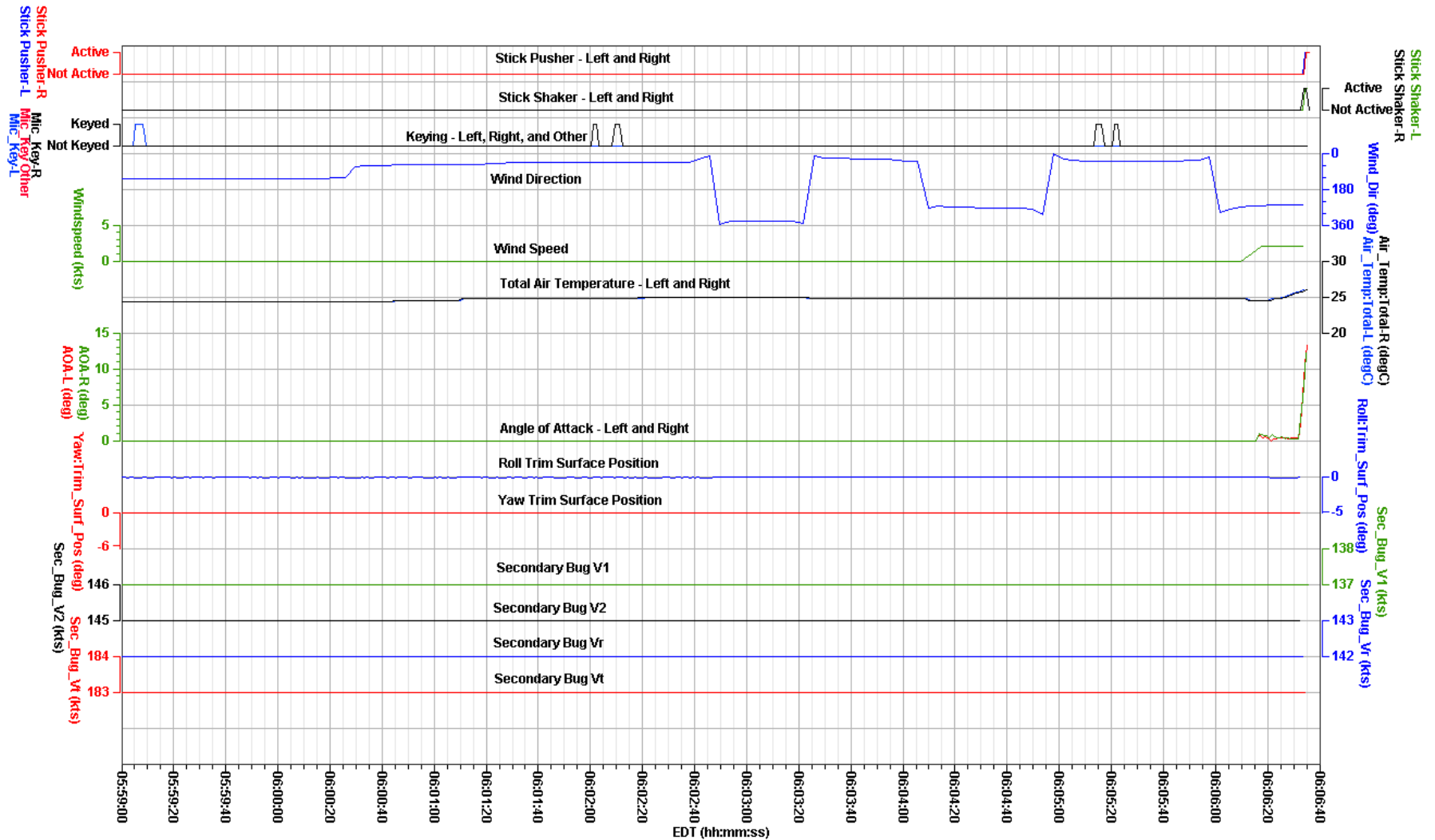
National Transportation Safety Board

Factual Report Plot 14

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 25 September 2006

Plot 3: 460 sec.

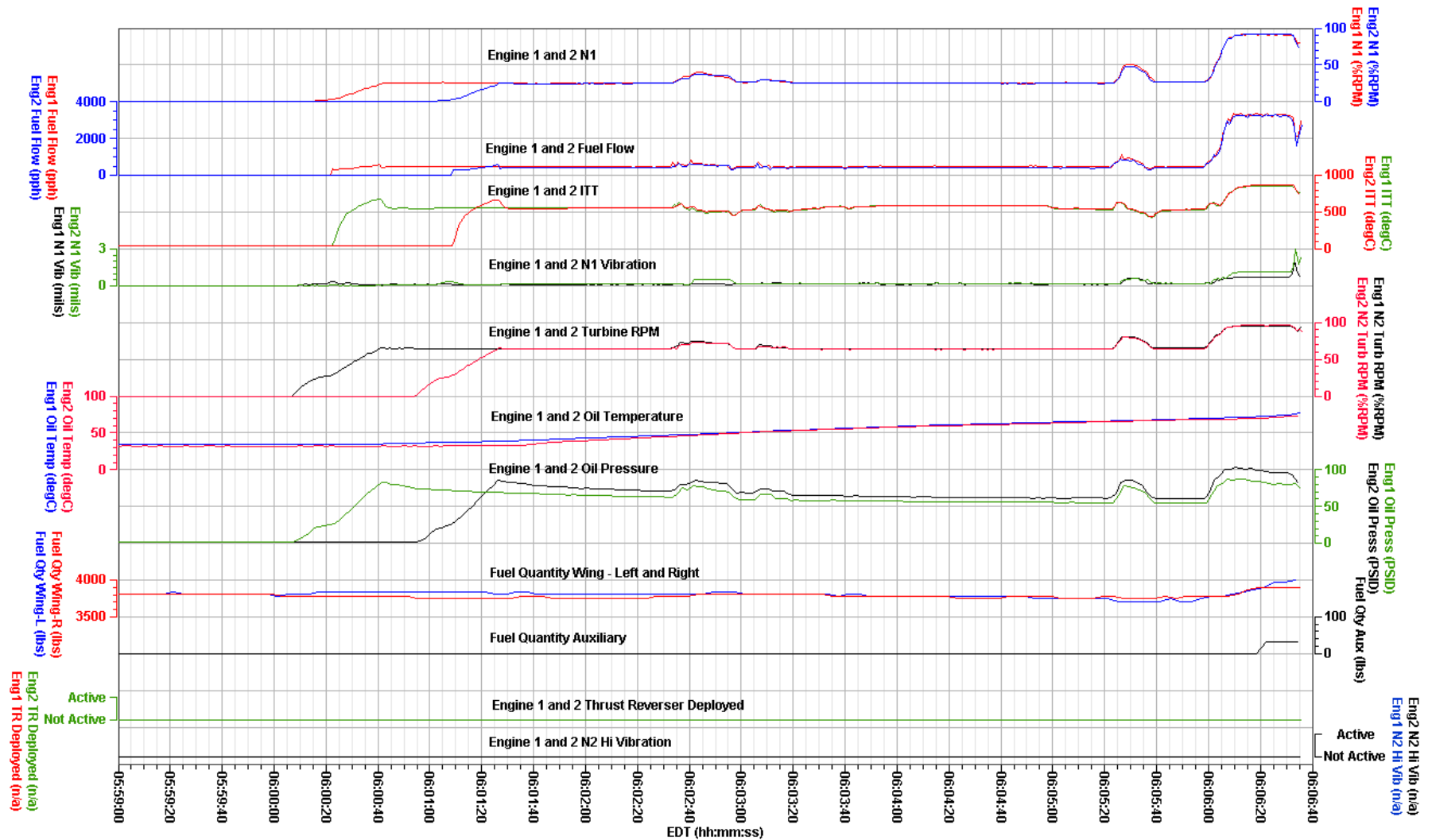
National Transportation Safety Board

Factual Report Plot 15

Comair, Canadair CL600-2B19, Flight 5191, N431CA

Location, Date: Lexington, KY, 08/27/06

NTSB No. DCA06MA064



Revised: 25 September 2006

Plot 4: Engine Parameters, 460 seconds

National Transportation Safety Board

Factual Report Plot 16

Tabular Data

A tabular listing of the data used to create Plots 1 through 16 can be found as Attachment 1 to this report. The time in the tabular listing is in EDT in terms of decimal seconds. The data is listed to the 1/128th of a second, based on the actual time each parameter is recorded. Attachment 1 is a comma separated value (.CSV) format file and is only available in electronic format.

Sarah McComb
Vehicle Recorder Division